GRADE 12 DIPLOMA EXAMINATION

Physics 30

June 1990

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **closed-book** examination consisting of **two** parts:

PART A has 49 multiple-choice questions each with a value of one mark.

PART B has four written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

GENERAL INSTRUCTIONS

Fill in the information required on the answer sheet and the examination booklet as directed by the examiner.

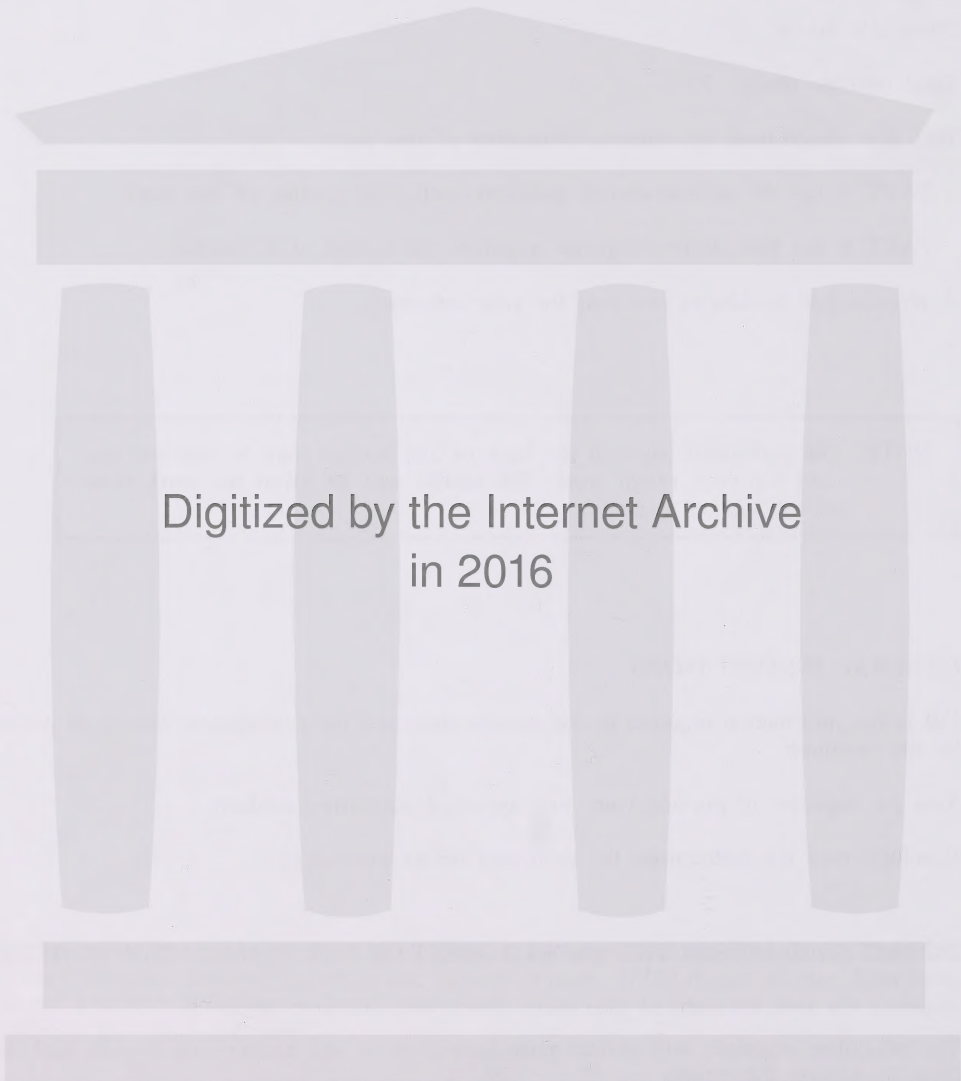
You are expected to provide your own approved scientific calculator.

Carefully read the instructions for each part before proceeding.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET.

The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.

JUNE 1990



PART A

INSTRUCTIONS

In this part of the examination, there are 49 multiple-choice questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully and decide which of the choices **best** completes the statement or answers the question. Locate that question number on the separate answer sheet provided and fill in the space that corresponds to your choice. **Use an HB pencil only.**

Example

This diploma examination is for the subject of

A. Biology
B. Physics
C. Chemistry
D. Mathematics

Answer Sheet

A	B	C	D
①	●	③	④

If you wish to change an answer, erase your first mark completely.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

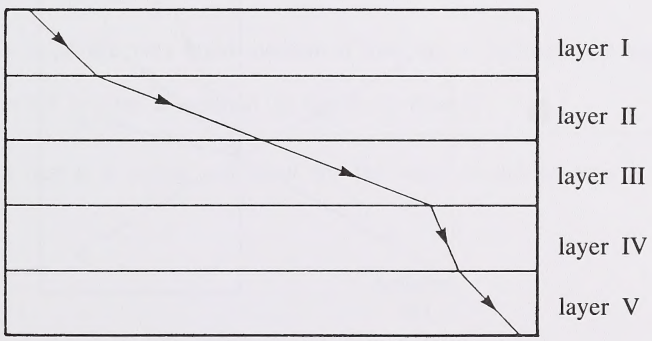
DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. A laser pulse of frequency 5.0×10^{14} Hz is aimed at a mirror 8.0×10^{4} m away and the reflected pulse is detected when it returns. The time between transmission and detection of the pulse is measured to be 5.5×10^{-4} s. The calculated speed of light is

A. 1.1×10^{8} m/s
B. 1.6×10^{8} m/s
C. 2.9×10^{8} m/s
D. 3.0×10^{8} m/s

Use the following information to answer question 2.

Light Incident on a Multiple Layer



2. If layer II contains air, which layer could be a vacuum?

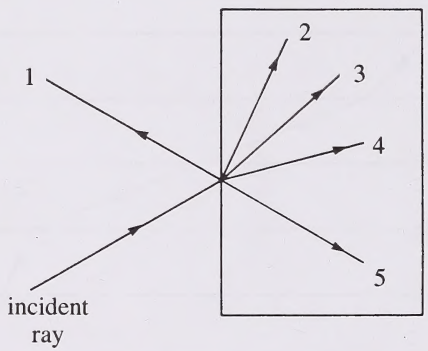
A. I
B. III
C. IV
D. V

3. Two waves of the same frequency with amplitudes of 4.3 cm and 7.8 cm travel at 330 m/s and are completely out of phase. The resultant amplitude of the combined wave is

A. 12.1 cm
B. 6.0 cm
C. 4.3 cm
D. 3.5 cm

Use the following information to answer question 4.

In the diagram below, a wave travelling from air to another medium is represented by an incident ray.



4. The most likely distribution of the wave energy would be in the directions of arrows

A. 1 and 2
B. 1 and 4
C. 5 and 2
D. 5 and 3

---

5. Monochromatic light of wavelength 6.20×10^{-7} m falls on a diffraction grating at normal incidence. A screen is placed at a distance of 3.50 m from the grating. If the fourth-order bright band appears at an angle of 30.0° from the incident ray, the grating spacing is

A. 2.02×10^{-5} m
B. 4.96×10^{-6} m
C. 1.24×10^{-6} m
D. 8.27×10^{-8} m

6. Römer gathered data to measure the speed of light by observing

A. lantern flashes on distant hills
B. light directly radiated by the sun
C. the movement of Jupiter's moons
D. light reflected from an octagonal mirror

Use the following information to answer question 7.

Statements Concerning the Nature of Light and Waves

I. Interference and diffraction of light are more easily explained by a wave model.

II. Interaction of light with some atomic particles is more easily explained by a particle model.

III. Waves require a very rigid medium if they are to propagate at high speeds.

IV. All waves require a medium in which to travel.

7. The statement that is a strong argument for the wave model of light is

A. I
B. II
C. III
D. IV

---

8. When Iceland spar (calcite) produces two rays from one incident ray, the emergent rays

A. travel at different speeds in air
B. have different cross-sectional areas
C. are polarized in perpendicular planes
D. are longitudinal waves for one ray and transverse waves for the other

9. If the Canadian flag is illuminated by a pure blue light, it will appear to be

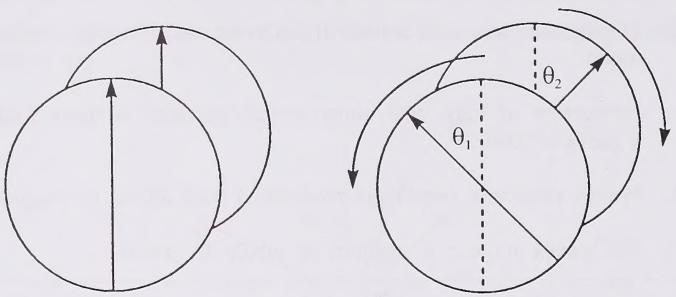
A. red and blue
B. red and white
C. black and blue
D. black and white

10. The prediction that light travels faster in water than in air is consistent with the

A. photon model of light
B. classical wave model of light
C. de Broglie wave model of light
D. classical particle model of light

Use the following information to answer question 11.

Polarizing Filters



before rotation after rotation

The arrows indicate the directions of the axes of polarization.

11. Two polarizing filters are rotated in opposite directions. If the axes of the filters are initially aligned, to what pair of angles could the filters be rotated so that there will be minimum transmission of light through the filters?

A. $\theta_1 = 22.5°$ and $\theta_2 = 22.5°$

B. $\theta_1 = 30°$ and $\theta_2 = 60°$

C. $\theta_1 = 40°$ and $\theta_2 = 60°$

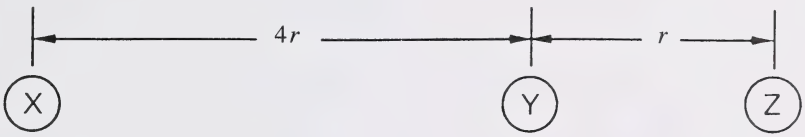
D. $\theta_1 = 90°$ and $\theta_2 = 90°$

---

12. The electrostatic force between an electron and a helium (He^{2+}) nucleus that are separated by a distance of 2.0×10^{-10} m is

A. 1.2×10^{-27} N
B. 2.3×10^{-18} N
C. 1.2×10^{-8} N
D. 2.3×10^{29} N

Use the following information to answer question 13.



Three objects are each negatively charged.

13. If there is no net force on Y, the relationship between the charges must be such that the charge on

A. X is 4 times greater than the charge on Z
B. X is 16 times greater than the charge on Z
C. Y is less than the charge on either X or Z
D. Y is greater than the charge on either X or Z

---

14. Coulomb's Law of electrostatic force and Newton's Law of Universal Gravitation each state that force is

A. calculated using the same proportionality constant
B. inversely proportional to the distance of separation between the objects
C. directly proportional to the product of charges (or masses) of the objects
D. directly proportional to the square of the distance of separation between the objects

15. A unit for electric field strength is

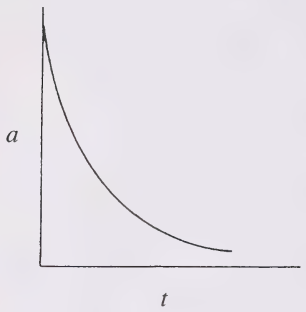
A. V
B. N/C
C. J/C
D. N/(C•m)

16. Electric potential difference may be defined in terms of

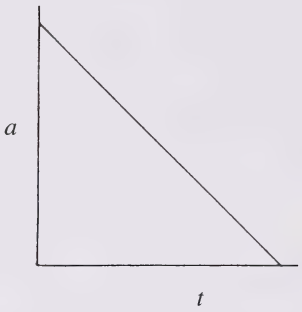
A. force per unit current on a wire
B. force per unit charge on a small test charge
C. work done per unit charge in moving a test charge
D. momentum change per unit current of an electric current

17. Two positively charged objects are held close together on a frictionless surface. If one of the objects is released, the acceleration of the released object can be represented by graph

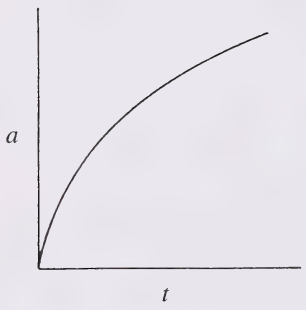
A.



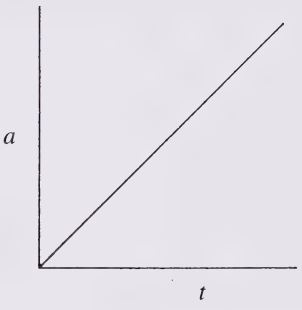
B.



C.



D.



18. What will be the speed of an electron that accelerates from rest through a potential difference of 5.0×10^{2} V?

A. 9.4×10^{6} m/s
B. 1.3×10^{7} m/s
C. 1.8×10^{14} m/s
D. 3.3×10^{16} m/s

19. Alternate layers of two different metals are components used in the construction of

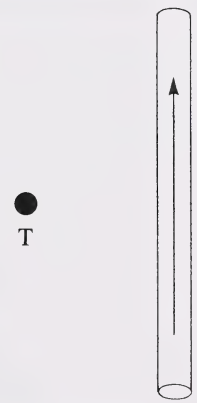
A. a voltaic cell
B. an induction coil
C. a photoelectric cell
D. a television picture tube

20. An electric crane lifts a 20.0 kg mass to a height of 10.0 m in 5.0 s. If the motor draws a current of 4.00 A and is 100% efficient, the minimum possible voltage applied to the motor must be

A. 390 V
B. 98 V
C. 39 V
D. 9.8 V

Use the following information to answer question 21.

Magnetic Field of a Current-Carrying Wire



The arrow shows the direction of the electron flow.

21. The direction of the magnetic field at point T is

A. to the left
B. to the right
C. into the page
D. out of the page

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22. An electron moving at 2.5×10^{7} m/s perpendicularly through a magnetic field of 0.60 T experiences an acceleration of

A. 1.5×10^{11} m/s^2
B. 4.2×10^{13} m/s^2
C. 2.4×10^{16} m/s^2
D. 2.6×10^{18} m/s^2

23. An electron travels at 4.5×10^{5} m/s at right angles to a uniform magnetic field. A wire that is 5.0×10^{-2} m long is perpendicular to the same field and experiences a magnetic force equal to the force on the electron. The current in the wire is

A. 1.4×10^{-12} A
B. 1.1×10^{-7} A
C. 2.3×10^{4} A
D. 7.1×10^{11} A

Use the following information to answer question 24.

Typical Wave Properties
I. reflection
II. refraction
III. diffraction
IV. interference

24. Which properties are common to light and radio waves?

A. I and II only
B. II and IV only
C. I, II, and III only
D. I, II, III, and IV

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25. In the vacuum of space, a changing electric field produces a changing

A. parallel magnetic field
B. parallel electric current
C. perpendicular magnetic field
D. perpendicular electric current

26. In an experiment similar to Hertz's, a student calculates that a spark jumps across the air gap and back again in 2.0×10^{-7} s. The wavelength of the electromagnetic wave transmitted by this coil is

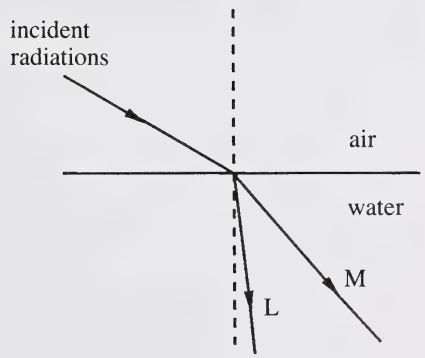
A. 6.0×10^{1} m
B. 6.0×10^{3} m
C. 1.5×10^{7} m
D. 1.5×10^{15} m

Use the following information to answer question 27.

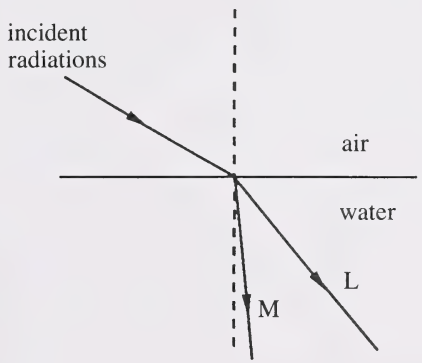
A visible light beam (L) and a microwave (M) both travelling in air are incident upon water at the same angle. The index of refraction of water is 1.3 for visible light and 9.0 for microwaves.

27. The diagram that **best** represents the paths the radiations would follow is

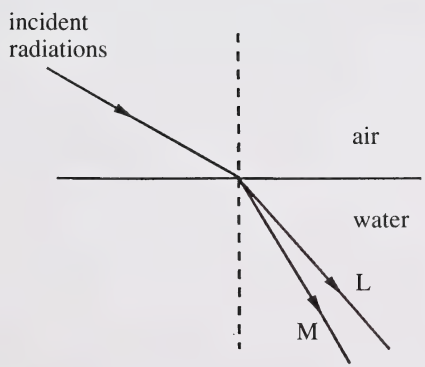
A.



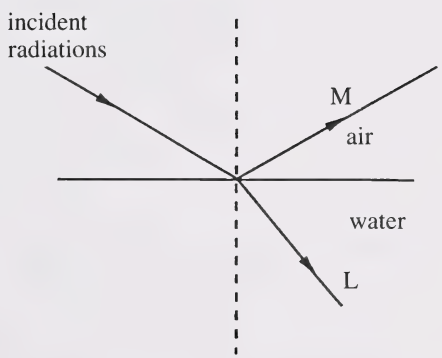
B.



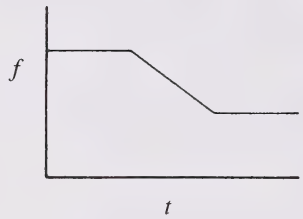
C.



D.

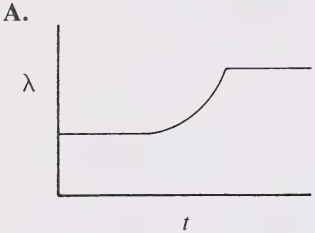


28. If the frequency-time graph for a particular electromagnetic wave generator is

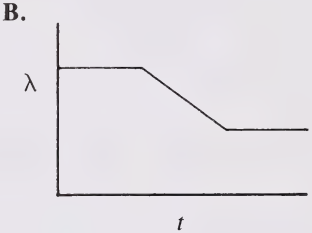


then the corresponding wavelength-time graph is

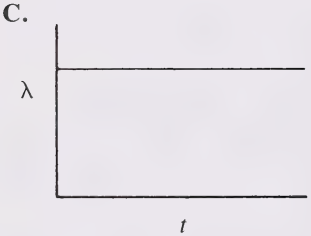
A.



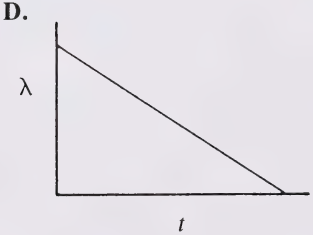
B.



C.



D.

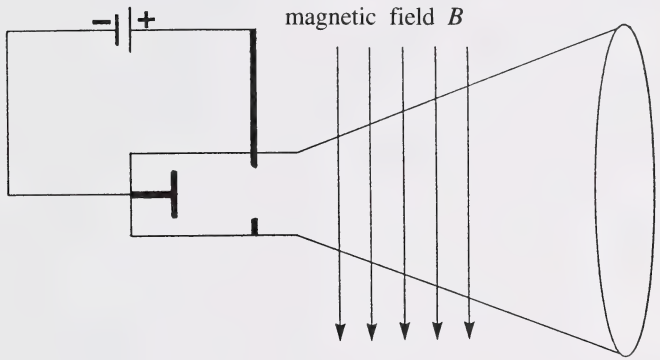


29. If a 5.0 A current releases 2.0 g of an element from a compound in 12 min, then the time required for a 0.50 A current to release 9.0 g of the same element is

A. 0.27 min
B. 5.4 min
C. 0.45 h
D. 9.0 h

Use the following information to answer question 30.

A Cathode-Ray Tube in an External Magnetic Field



30. The particles in the cathode-ray tube will be deflected in a direction

A. into the page
B. out of the page
C. toward the top of the page
D. toward the bottom of the page

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31. Which of the following forms of radiation **cannot** be detected by a photographic plate?

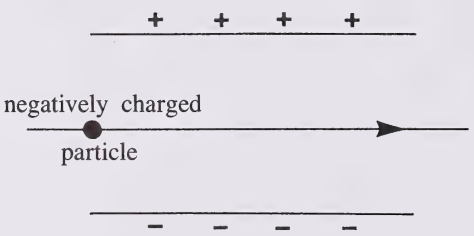
A. X-ray
B. Infrared
C. Radiowave
D. Ultraviolet

32. A nickel surface of work function 5.0 eV is illuminated with ultraviolet light of wavelength 2.0×10^{-7} m. The stopping voltage is

A. 1.8 V
B. 1.5 V
C. 1.2 V
D. 0.88 V

Use the following information to answer question 33.

A Charged Particle Moving in Gravitational and Electric Fields



33. A negatively charged particle of mass 3.0×10^{-14} kg moves horizontally through a vertical electric field of intensity 6.1×10^{4} N/C. The number of excess electrons on the particle is

A. 0.3
B. 1
C. 3
D. 30

---

34. The relationship between the shortest wavelength λ_{min} produced by an X-ray tube and the accelerating voltage V is represented by

A. $\lambda_{min} = hc/q_eV$

B. $\lambda_{min} = Vcq_e/h$

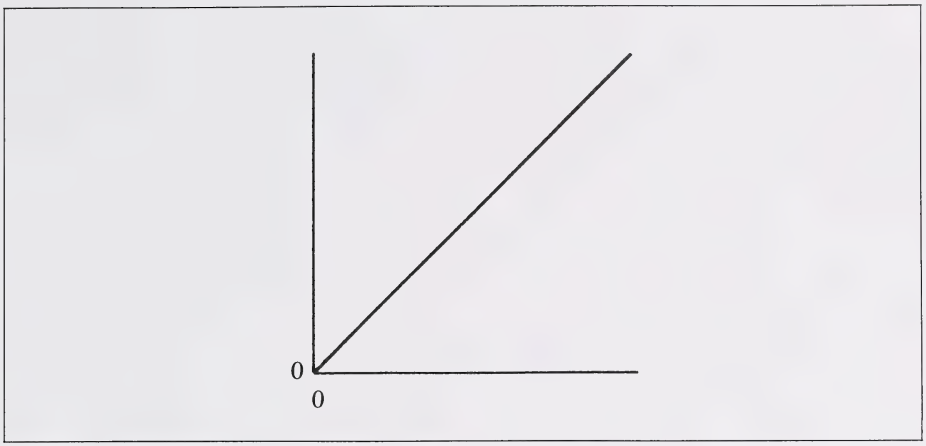
C. $\lambda_{min} = Vq_e/hc$

D. $\lambda_{min} = Vq_ec/h$

35. Alpha particles are scattered by gold foil. The evidence that most of the mass of the atom is concentrated in a small nucleus is that

A. all alpha particles experience slight deflection
B. some alpha particles are absorbed by the gold foil
C. some alpha particles are deflected through large angles
D. all alpha particles pass through the foil with no deflection

Use the following graph to answer question 36.



36. A possible title (caption) for this graph is

A. photon speed as a function of frequency
B. photon energy as a function of frequency
C. photon energy as a function of wavelength
D. photon frequency as a function of wavelength

---

37. When an electron makes a transition between the second and fourth energy levels in a hydrogen atom, the magnitude of the energy change of the atom is

A. 4.1×10^{-19} J
B. 2.7×10^{-19} J
C. 2.6×10^{-19} J
D. 1.6×10^{-19} J

38. Classical wave theory **cannot** account for the

A. diffraction of X-rays
B. polarization of X-rays
C. refraction of microwaves in water
D. existence of a photoelectric threshold frequency

39. The first experimental evidence that contradicted Newton's laws of motion was

A. Compton's evidence that X-rays act like particles
B. the discovery of absorption lines in the solar spectrum
C. the measurement of discrete energy levels in the hydrogen atom
D. that, for high kinetic energies, the measured speed of particles is always less than the speed of light

Use the following information to answer question 40.

Data collected during an experiment on high-speed electrons:

Speed (10^8 m/s)	Charge-to-Mass Ratio (10^{10} C/kg)
1.0	16.6
2.0	13.1
2.5	9.7
2.9	4.5

40. The data indicate that the

A. electron mass is a variable that is held constant
B. charge of an electron decreases as its speed increases
C. charge-to-mass ratio of an electron is independent of its speed
D. charge-to-mass ratio decreases as the relativistic mass increases

---

41. To explain the Compton effect, it is necessary to

A. attribute momentum to the photon
B. attribute wavelength to the electron
C. deny conservation of energy for X-ray interactions
D. assume that fast electrons have a greater mass than slow electrons

42. The speed of an electron that has the same momentum as a photon with a wavelength of 5.10×10^{-7} m is

A. 7.10×10^{2} m/s
B. 1.01×10^{3} m/s
C. 1.43×10^{3} m/s
D. 2.98×10^{8} m/s

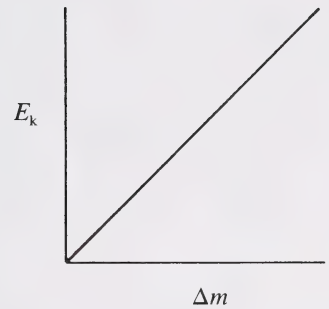
43. The momentum of a photon that has an energy of 4.0×10^{-19} J is

A. 1.2×10^{-27} kg•m/s
B. 1.3×10^{-27} kg•m/s
C. 7.5×10^{-27} kg•m/s
D. 8.8×10^{-27} kg•m/s

44. The de Broglie wavelength of a proton moving at 1.1×10^{7} m/s is

A. 2.5×10^{-20} m
B. 3.6×10^{-14} m
C. 6.6×10^{-11} m
D. 4.0×10^{-7} m

Use the following graph to answer question 45.



The graph shows the kinetic energy of an electron (E_k) as a function of its change in mass (Δm).

45. The slope of the graph is equal to

A. h/c
B. h
C. c
D. c^2

---

46. A distinguishing characteristic of the Schrödinger equation is that it

A. is simpler than Bohr's model
B. provides a physical model of the atom
C. applies only to hydrogen and hydrogen-like atoms
D. has solutions that indicate probabilities rather than certainties

47. In an experiment using an electron microscope to locate objects moving at a speed of 2.0×10^3 m/s, there will be the least percentage error in determining the position of

A. a proton
B. a neutron
C. a molecule
D. an electron

Use the following information to answer question 48.

In an experiment designed to investigate the wave characteristics of subatomic particles, the following data were obtained:

Trial Number	Mass (10^{-30} kg)	Velocity (10^{6} m/s)	Wavelength (10^{-10} m)
1	1.0	3.3	2.0
2	2.0	1.7	2.0
3	3.0	1.0	2.2
4	4.0	1.0	1.6
5	5.0	2.0	0.6
6	5.0	3.0	0.4

From the data, the following interpretations may be made:

I. The wavelength of the particle varies inversely with the momentum of the particle.

II. The wavelength of the particle varies directly with the momentum of the particle.

III. The wavelength of the particle varies inversely with the mass of the particle if the velocity is kept constant.

IV. The wavelength of the particle varies directly with the mass of the particle if the velocity is kept constant.

48. The valid interpretations are

A. I and III
B. I and IV
C. II and III
D. II and IV

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49. An electron moves with a velocity of 3.0×10^{6} m/s. This velocity can be measured to an accuracy of 10%. The greatest accuracy to which we could, in principle, measure the position of the electron is of the order of

A. 10^{-10} m
B. 10^{-12} m
C. 10^{-24} m
D. 10^{-37} m

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE PART OF THE EXAMINATION. PROCEED DIRECTLY TO PART B.

PART B

INSTRUCTIONS

In this part of the examination, there are four written-response questions for a total of 21 marks. All numbers used in the questions are to be considered as the result of a measurement.

Write your solutions in the examination booklet as neatly as possible.

Your solutions **must show all** pertinent explanations, calculations, and formulas. Full marks will be assigned **only** to those solutions that **show** all pertinent explanations, calculations, and formulas.

All numerical answers must be given correct to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

START PART B IMMEDIATELY.

FOR DEPARTMENT USE ONLY

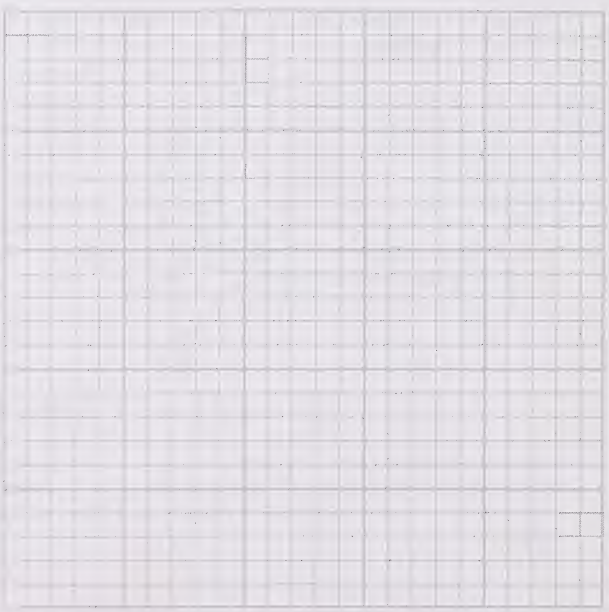
Use the following information to answer question 1.

In a modified Millikan apparatus, a small charged object that has a mass of 2.5×10^{-6} kg is suspended by the electric field between charged parallel plates. The table shows how the balancing voltage depends on the distance between the plates:

Plate separation (mm)	Balancing voltage (V)
1.1	10
2.0	17
2.4	21
3.1	27
3.5	30
5.0	42

(2 marks)

1. a. On the grid provided, plot a graph of balancing voltage and plate separation, with the manipulated variable on the horizontal axis.



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b. Calculate the slope of the graph. What physical quantity or quantities does this slope represent? **(2 marks)**

c. Use a suitable averaging technique to determine the magnitude of the charge on the suspended object. **(3 marks)**

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(5 marks)

2. Microwave ovens have glass (or plastic) windows. These windows are constructed with metallic mesh having holes about 3 mm in diameter. Most microwave ovens operate at a frequency of 2.45×10^9 Hz.

a. Explain the function of the metallic mesh and explain why the mesh must be made of a metal rather than a nonmetallic substance.

b. Explain, with supporting calculations, why the holes of the mesh are about 3 mm in diameter.

c. Give an alternative design for the window that would serve the same purpose as the glass/mesh combination.

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3. A medallion with a total surface area of 205 cm^2 is to be gold-plated to a thickness of 0.101 mm. Gold has a density of 19.3 g/cm^3, a valence of 3, and an atomic mass of 197 g/mol. Calculate the current required to plate the medallion in 9.87 h. Record your answer to three significant digits. **(4 marks)**

(Note: If you are unable to calculate the mass of the plated gold, use the hypothetical value of 36.0 g. A solution using the hypothetical value is worth a maximum of **2 marks**.)

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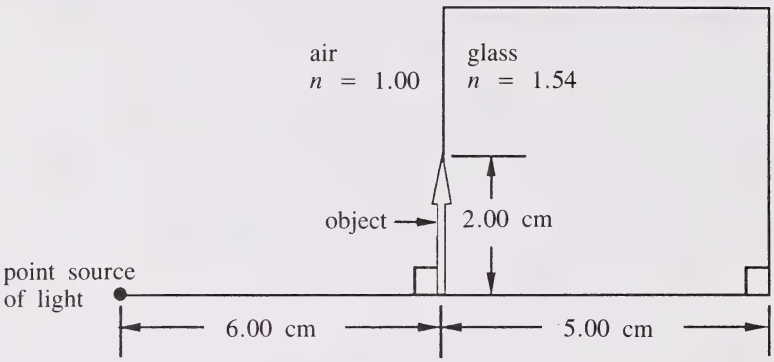
Use the following information to answer question 4.

Shadow on a Glass Block

This diagram is not drawn to scale.



Light from a point source illuminates an object that is 2.00 cm high and is attached to the front face of a glass block. The block is 5.00 cm thick and has a refractive index of 1.54. A shadow appears on the back of the glass block.

(1 mark)

4. a. Sketch the ray from the point light source that defines the tip of the shadow cast by the object.

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b. Given that the object is 6.00 cm from the light source, determine the height of the shadow. Record your answer to the nearest 0.01 cm.

(4 marks)

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

TEAR-OUT PAGE

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TEAR-OUT PAGE

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M1 M2 M3 M4

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PHYSICS 30

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PHYSICS 30